PB-214 883

WATER QUALITY CONTROL STUDY, BRANTLEY RESERVOIR, PECOS RIVER BASIN, NEW MEXICO

Federal Water Pollution Control Administration
Dallas, Texas

October 1966

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WATER QUALITY CONTROL STUDY

BRANTLEY RESERVOIR

PECOS RIVER BASIN

NEW MEXICO

This investigation disclosed a need for storage for water quality control purposes in the proposed Brantley Reservoir. These conclusions are based on the results of economic, demographic and engineering studies.

Prepared for

U. S. DEPARTMENT OF THE INTERIOR

Bureau of Reclamation

Albuquerque Development Office--New Mexico

U.S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
South Central Region
Dallas, Texas

OCTOBER 1966

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I. INTRODUCTION

Request and Authority

In a letter dated December 21, 1962, the Albuquerque Development Office of the Bureau of Reclamation requested the Public Health Service* to investigate and report on the need for and value of storage for water quality control purposes in the proposed Brantley Reservoir.

This study has been made in accordance with the Federal Water Pollution Control Act, as amended, (33 U.S.C. 466 et seq.).

Purpose and Scope

This study was made to examine the probable effects of the proposed project on water quality in the Pecos River; to determine the benefits or damage resulting from changes in water quality; to evaluate the suitability of the water for proposed water quality uses; and, to determine the need for and the value of storage for regulation of streamflow for the purpose of water quality control. The study area encompasses all of Eddy County located in the southeastern portion of New Mexico. The need for streamflow regulation was studied for present conditions and anticipated future conditions to the year 2070.

Acknowledgments

Appreciation is expressed to the following organizations who assisted during the study:

New Mexico State Department of Health
New Mexico State Planning Office
New Mexico State Engineers Office
Bureau of Reclamation, Albuquerque, New Mexico
Geological Survey, Carlsbad, New Mexico
Carlsbad Caverns National Park
Local Government officials of the city of Carlsbad

*In accordance with the Water Quality Act of 1965 (Public Law 89-234) approved October 2, 1965, the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.) is now administered through the Federal Water Pollution Control Administration.

II. SUMMARY OF FINDINGS AND CONCLUSIONS

Summary of Findings

1. The Bureau of Reclamation, Albuquerque, New Mexico is conducting a feasibility study of Brantley Reservoir on the Pecos River, about 15 miles northwest of Carlsbad, New Mexico.

2. The study area, consisting of Eddy County in southeastern New Mexico, had a total 1960 population of 50,783. The cities of Carlsbad and Artesia with 25,541 persons and 12,000 persons, respectively, accounted for all of the urban population.

3. Present water use by Carlsbad is almost 6 million gallons per day (mgd) with a per capita demand of 219 gallons per capita per day (gpcd).

4. The principal waste producer in the study area is the city of Carlsbad which presently discharges 3.7 mgd to the Pecos River. The waste has a population equivalent (P.E.) of about 2,000.

5. The mineral content of the Pecos River at Carlsbad is high, averaging nearly 3,000 milligrams per liter (mg/l) of total dissolved solids. The chemical quality of ground water which supplies the city of Carlsbad is good, averaging less than 500 mg/l of total dissolved solids.

Conclusions

1. The population of the study area is expected to increase to approximately 143,000 in 2020, and 301,000 in 2070 with Carlsbad increasing to about 90,000 in 2020 and 200,000 in 2070. The anticipated workers in service industries, as influenced by tourism in the area, is largely responsible for this growth.

2. Municipal and industrial water demand for Carlsbad is expected to increase to approximately 40 mgd in 2020, and 85 mgd in 2070.

3. Releases from the study reservoir for water quality control purposes would prevent nuisance conditions from occurring in the Pecos River from Carlsbad to Red Bluff

Reservoir, and would maintain dissolved oxygen levels in the stream which will support fish life and permit recreation and other uses of the stream.

4. By the year 1990, there is a need for storage to provide regulation to meet water quality control needs in the Pecos River. The draft-on-storage to meet these requirements is about 4,600 acre-feet per year in 2020 and 21,600 acre-feet per year in 2070.

5. The annual value of benefits for storage to meet water quality control requirements to the year 2070, based on the cost of the most likely alternative, is $33,000. The benefit to storage that is available in Brantley Reservoir for this purpose (to yield 7,000 acre-feet per year) amounts to $22,000 annually.

6. Benefits to water quality control storage in Brantley Reservoir will be widespread in scope. The need for storage for water quality control and the consequent benefits are based on providing adequate treatment for sewage effluent that is discharged to the study stream.

III. PROJECT DESCRIPTION

The proposed Brantley project would be located about 4 miles downstream from the existing McMillan Dam on the Pecos River in Eddy County, New Mexico. (See figure III-1 following page X-2.) Since McMillan would be partially inundated by the project, Brantley would provide replacement conservation storage presently in McMillan. Present allocation for storage in Brantley Reservoir, with multi-purpose use, would be 736,000 acre-feet for flood control, 40,000 acre-feet for irrigation, 2,000 acre-feet minimum pool for fish and wildlife and recreation, and 101,400 acre-feet for sediment reserve within the 143,400 acre-feet of conservation storage. The surface area at the top of the conservation pool at the end of 100 years would be 7,880 acres. Principal features of the reservoir are shown in table III-1.

Table III-1

Principal Features - Brantley Reservoir

	Elevation (ft., m.s.l.)	Capacity (acre-feet)
Surcharge	3,300.7	360,000
Flood Control (Exclusive)	3,289.9	376,000
Conservation	3,270.4	143,400
Inactive	3,227.2	2,000
Dead	3,219.0	600
Streambed	3,200.0	0

Source: Bureau of Reclamation 1/

IV. STUDY AREA DESCRIPTION

The study area consists of Eddy County in southeastern New Mexico. General features of the area are shown in figure III-1. The study area is on the northern edge of the Chihuahuan Desert that extends deep into central Mexico. North and east of the city of Carlsbad lie the great plains of New Mexico and Texas. The Guadalupe Mountains form a barrier to the west.

Soils of the Carlsbad area vary from a light sandy loam to a light clay loam, with a high lime content, and are easy to work. The best soils are very fertile and especially well adapted to growing cotton and alfalfa.

The climate is characterized by abundant sunshine and, generally, low humidities. The annual mean rainfall at Carlsbad is approximately 13 inches. Much of the year's moisture falls in brief, but sometimes intense, thundershowers during the summer months. 2/ The annual mean temperature at Carlsbad is about 63°F., with monthly mean temperatures varying from 44°F. in January to 81° in July. 3/ Because of the dry climate, almost all cropland is under irrigation; nearly 60,000 acres were harvested in 1959.

Carlsbad and Artesia, with 1960 populations of 25,500 and 12,000, respectively, are the principal communities in the study area and potash and petroleum mining are the principal industries.

V. WATER RESOURCES OF THE STUDY AREA

General

Control of the water resources in New Mexico was vested in the State at an early date in order to assure dependable supplies to those who developed them and to prevent waste.

"New Mexico law provides that the surface and underground waters of the State belong to the public and are subject to appropriation for beneficial use. Such use is the basis, the measure, and the limit to the right to use of water, and priority in time gives the better right. The underlying principle is known as the appropriative doctrine of water rights. Where it applies, the mere physical presence of water upon or within or adjacent to land does not confer upon the owner of the land ownership of the water or even a right to its use. Rather, water rights are established exclusively through use and rights established first must be served first." 3/ Water rights in New Mexico are administered by the State Engineer.

Quantity of Water Available

The quantity of flow in the Pecos River at Carlsbad was based on period-of-record data (43 years) developed in operation studies by the Bureau of Reclamation. Yearly flows at various exceedence frequencies, both with and without Brantley Reservoir in place, are shown in table V-1.

Table V-1

Streamflow in the Pecos River at Carlsbad

Exceedence Frequency (%)	Flow (1,000 acre-feet per year)	
	Without Brantley	With Brantley
98	17	18
95	21	20
90	25	22
80	31	27
50	48	42

There are presently three reservoirs controlling the flow of the Pecos River in the study area: Lake McMillan at river mile 484, Lake Avalon at river mile 470, and Red Bluff at river mile 319.

McMillan Reservoir, 19 miles northwest of Carlsbad was completed in 1893. The original capacity of 90,000 acre-feet has been

reduced by sediment to about 33,600 acre-feet which is used for irrigation and recreation. The proposed Brantley Reservoir would partially inundate McMillan.

Avalon Reservoir, four miles north of Carlsbad, has a capacity of approximately 5,000 acre-feet and functions principally in regulating irrigation diversions to a canal system which serves some 25,000 acres. The Carlsbad Irrigation District took over operation of the project in 1949.

Red Bluff Dam is located in Texas about 8 miles south of the New Mexico-Texas State line, with the reservoir extending into Eddy County, New Mexico. The project is owned and operated by the Red Bluff Water Power Control District. The reservoir has a capacity of 310,000 acre-feet to use for hydroelectric power generation and irrigation of 145,000 acres.

Ground Water

The supply of surface water was almost entirely appropriated in most areas at an early date and increased demands for water for municipal and industrial, domestic, stock, and irrigation in recent years have been supplied mostly from ground water sources. Use of most of the ground water in the area is administered by the State Engineer of New Mexico.

"All ground water in the State belongs to the public and is subject to public administration, but its development and use are administered only in designated areas where such administration is deemed to be in the public interest and the interest of holders of valid water rights. The statutes provide that when the State Engineer finds the waters of an underground stream, channel, artesian basin, reservoir or lake has reasonably ascertainable boundaries, and when he so proclaims, he assumes jurisdiction over the appropriation and use of such waters." 3/ Two of these "underground-water-basins" are located in Eddy County, the entire Carlsbad basin, and part of the Roswell artesian basin.

The Carlsbad area is solely dependent on ground water for its municipal and industrial needs, and partially for irrigation and mining. The two main water bearing formations in the study area are the Capitan Limestone aquifer and an alluvial fill aquifer. The city of Carlsbad obtains its water supply from 8 wells that tap the Capitan Limestone, some 7 miles from town. In 1960, pumpage from the wells was 5.9 mgd. 4/ The aquifer in the Capitan Limestone, recharged chiefly by precipitation upon the outcrop area, constitutes an underground tributary to the Pecos River. The major point of discharge is the Carlsbad Springs, above the city of Carlsbad,

which also discharges leakage from Lake Avalon and irrigation canals. Increases in discharge are directly correlated with heavy rains. The average discharge from this aquifer, including pumpage, is approximately 60 cubic feet per second (cfs). Pumping from wells in the limestone aquifer has not caused a marked decline in water levels, and the principal effect has been reduction in spring discharge. The annual recharge rate has been estimated to be 60,000 acre-feet.

The alluvial aquifer along the Pecos River, the principal ground water source for irrigation, is recharged by precipitation, flood flows, seepage from the Pecos River, and seepage of the irrigation diversion water. There has been a marked decline in water levels of this aquifer due to increases in irrigation pumpage in recent years. Well yields of more than 1,000 gallons per minute are common. 3/

In 1958, a total of 33,500 acre-feet of water was withdrawn from the ground in the Carlsbad area. Of this amount 13,000 acre-feet was pumped from the Capitan Limestone and 20,500 acre-feet from the alluvial valley fill.

In 1957, 54,000 acre-feet of ground water was pumped with 36,700 acre-feet of water used to supplement surface water irrigation, resulting in a water duty of 4.4 acre-feet per acre. In 1958, about 24,500 acre-feet of water was pumped for irrigation, of which 12,500 acre-feet was pumped in areas of supplementary ground water use. In these areas the rate of application was 3.8 acre-feet per acre. This decrease in irrigation water was due to more precipitation during 1958.

Quality of Water Available

Surface Water

A summary of the present water quality in the study area is shown in table V-2.

The mineral content of the Pecos River within the boundaries of the study area is high. The difference in the mineral quality between the two locations is caused by irrigation return flows and saline ground water seepage into the stream. The large mining industries in the area do not discharge waste water into the Pecos River.

Table V-2

Summary of Present Water Quality Conditions

Pecos River at Carlsbad, New Mexico

(Period of record equals 5 years collected on an erratic sampling schedule between 1946 and 1957. Approximately 30 composite sample analyses per test year)

	Concentrations in mg/l		
	Total Dissolved Solids	Chlorides	Sulfates
Arith. mean	2,378	436	1,100
Maximum	3,200	665	1,420
Minimum	1,730	210	925

Pecos River east of Malaga, New Mexico

(Station located approximately 27 miles downstream from Carlsbad. Period of record equals 11 years between 1946 and 1957, with the exception of 1954. Approximately 30 composite sample analyses per year)

	Concentrations in mg/l		
	Total Dissolved Solids	Chlorides	Sulfates
Arith. mean	3,527	880	1,421
Maximum	9,100	3,660	2,320
Minimum	407	36	154

Source: Geological Survey 5/

Ground Water

Generally, water in the Capitan Limestone is good, whereas that in the alluvial aquifer is of lesser quality. Typical values of chemical constituents in water in the Capitan Limestone are: Total Dissolved Solids of 500 mg/l; Chlorides of 25 mg/l; and Sulfates of 50 mg/l. 4/

Because of recharge of slightly saline water to the limestone system north of Carlsbad, the water under parts of Carlsbad is highly mineralized. Farther to the southwest, the water is of better quality and the city has recently extended its well field to that locality to obtain this water. Small supplies of water of acceptable quality can be obtained from perched aquifers in the less permeable limestone west of Carlsbad. 3/

VI. THE ECONOMY

An economic study was made of the study area and the resulting projections of population and industrial growth serve as a basis for estimating future water use requirements and waste discharges.

Present

Economic Geography

The study area consists of Eddy County in the semiarid climate of southeastern New Mexico. The city of Carlsbad is synonymous with potash, because the economy of the trade center has long been strictly tied to potash activity.

Tourism is significent to the economy of the area; in addition to the healthful climate, the study area is surrounded with recreation areas and items of historic interest. Carlsbad Caverns National Park, 28 miles southwest of the city of Carlsbad, has the largest caverns on the North American continent. The average attendance between 1958 and 1962 was over 500,000 persons annually, ranging from 16,000 persons in November to 112,000 persons in July. 6/

The 1960 population of the study area was 50,783, an increase of about 110 percent in the past two decades. The urban population 37,500, was responsible for this growth, increasing 235 percent during this same period. The urban growth reflects an increase of 260 percent in service industries primarily associated with tourism in the area. Since 1920, the population of the study area has been increasing at an average annual rate of 4 3/8 percent. This compares with an increase of 2 1/2 percent for the State of New Mexico and 1 1/2 percent for the national average.

Resources Within the Area

Mining has been the backbone of the economy of Carlsbad and the surrounding area for the past few decades. Potash and petroleum production are the principal mining industries in the study area.

The vast potash deposits near Carlsbad have accounted for almost 90 percent of the annual potash production in the United States. The annual production of potash in the area has increased over 200 percent in the past 15 years. In 1960, more than 4,000 people were employed by this industry, which contributed 73 percent of the

total value of mineral output in the study area. In addition, sodium chloride, magnesium oxide and hydrochloric acid are being recovered as by-products of the potash industry. The production of marketable potassiums salts is shown below in table VI-1.

Table VI-1

Production of Marketable Potassium Salts

Year	K_2O Equivalent (thousand short tons)	Value of Production (1,000's of 1960 dollars)
1945	733	44,412
1950	1,073	41,236
1955	1,884	76,723
1960	2,440	80,023

Source: Bureau of Mines 7/

Petroleum production has increased 200 percent since 1956; in 1961 Eddy County ranked third in the state and supplied 12.5 percent of New Mexico's oil production. Petroleum production between 1956 and 1961 is shown in table VI-2.

Table VI-2

Petroleum Production
(thousand barrels)

1956	4,522
1957	5,900
1958	6,574
1959	8,180
1960	11,323
1961	14,114

The value of mineral production for the study area is shown in table VI-3.

Table VI-3

Value of Mineral Production

Year	(1,000's of 1960 dollars)
1953	60,569
1954	48,107
1955	74,098
1956	90,820
1957	90,977
1958	85,869
1959	94,149
1960	110,996
1961	131,057

1960 constant dollars

Source: Bureau of Mines 7/

The acres of cropland harvested in the study area have decreased only 13 percent since 1944. Due to the dry climate, almost all cropland is under irrigation.

Cotton, and alfalfa are the principal crops, and livestock feed is produced in abundance. Vegetables and fruits support these major enterprises.

The trends in agricultural activity are shown in table VI-4.

Table VI-4

Agricultural Activity

Year	Cropland Harvested (acres)	Value of All Crops Sold (1000's of 1960 dollars)	Value of Livestock and Livestock Products Sold (1000's of 1960 dollars)
1944	67,224	$ 3,061	$2,321
1949	66,613	8,274	3,089
1954	59,336	11,618	3,100
1959	58,443	11,887	6,917

Source: Bureau of the Census 8/

The development of manufacturing in the area has experienced a slower rate of growth than the State of New Mexico. During the last decade employment in manufacturing in Eddy County experienced an increase of 42 percent as compared to 78 percent for the state. In 1960, 939 workers were employed in manufacturing, which comprised 5 percent of the labor force.

Future

The economic projections for the years 2020 and 2070 were made after evaluating the potential development of mining, agriculture, manufacturing and tourism in the study area.

Mining has been the major contributor to the economy in the past and is expected to expand even more in the future. At the present level of production, it would take more than 150 years to exhaust known potash deposits in the area. 9/ The need for potassium compounds is expected to increase in both agciculture and the chemical industry. Oil resources in the Carlsbad area have not been developed to any great degree and the future should bring increased activity in this field. The four major producing fields in 1960 have a known recoverable reserve of more than 20 times the 1960 production. 10/ In 1960, the mining industry employed 4,731 people, which was 26 percent of the labor force. The employment by this industry is expected to increase to 9,300 in 2020 and 10,000 in 2070. Mining is expected to be the principal industrial water user in the future.

Employment in agriculture has decreased since 1950, although acres of cropland harvested have been fairly constant and the value of output of agricultural products has increased. With increasing knowledge and technological advances, agricultural production is expected to increase, while employment in this category will decrease from 1,508 in 1960 to about 700 in 2020 and then remain relatively constant until the year 2070.

An abundance of raw materials such as petroleum, gas and by-products of potash production are expected to give impetus to the production of chemicals and allied products. The dry climate lends itself to the manufacturing of fabricated metals. The employment in manufacturing is expected to increase from 939 in 1960 to 3,650 in 2020 and to 11,600 in 2070.

The service industries which include sales, insurance, finance, personal services, and transportation employed 57.2 percent of the labor force, or 10,600 workers, in 1960. Tourism due to the nationally renowned Carlsbad Caverns is contributing an ever increasing value to the economy. An increase in tourists, attracted by the healthful climate and recreational facilities in the area,

is expected, thus necessitating more workers in the service industries. This industry is expected to employ 70 percent of the labor force, or 36,820 workers, in 2020 and 76 percent or 84,700 workers in 2070.

A summary of the present and anticipated future employment is shown in table VI-5.

Table VI-5

Study Area Employment Present and Projected

	1960*		2020		2070	
	Number	Percent	Number	Percent	Number	Percent
Agriculture	1,508	8.2	700	1.3	700	0.6
Forestry & Fisheries	4	-	30	0.1	100	0.1
Mining	4,731	25.6	9,300	17.7	10,000	9.0
Manufacturing	939	5.1	3,650	6.9	11,600	10.4
Service Industries	10,600	57.2	36,820	70.0	84,700	75.9
Unemployed	728	3.9	2,100	4.0	4,400	4.0
Labor Force	18,510	100.0	52,600	100.0	111,500	100.0
Total Population	50,783	-	143,000	-	301,000	-
Labor Force Participation Rate	-	36.4	-	36.8	-	37.1

*Source: Bureau of Census 11/

High, low, and most probable future population projections of the study area were made. These estimates were based on an assumed range of areal economic development coupled with assumptions of migration and natural increase. The high projection reached 218,000 by the year 2020 and 560,000 by the year 2070. Similar figures for the low projection are 108,000, and 165,000 in 2020 and 2070, respectively. The most probable estimate of 143,000 in 2020 and 301,000 in 2070, which was adopted for use in this study, is based on the expected resource development and employment. This is an annual growth rate of 1.6 percent, compared to 2.3 percent for New Mexico. 12/

Since future municipal and industrial water requirements are based, in part, on anticipated populations, any deviation from those used in the report (most probable estimate) could significantly alter the projected water needs. If the high population projections occurred, water requirements could be increased by some 150 percent in 2020 and 185 percent in 2070. Similarily, if the low predictions developed, water needs could be reduced by 75 percent in 2020 and 55 percent in 2070.

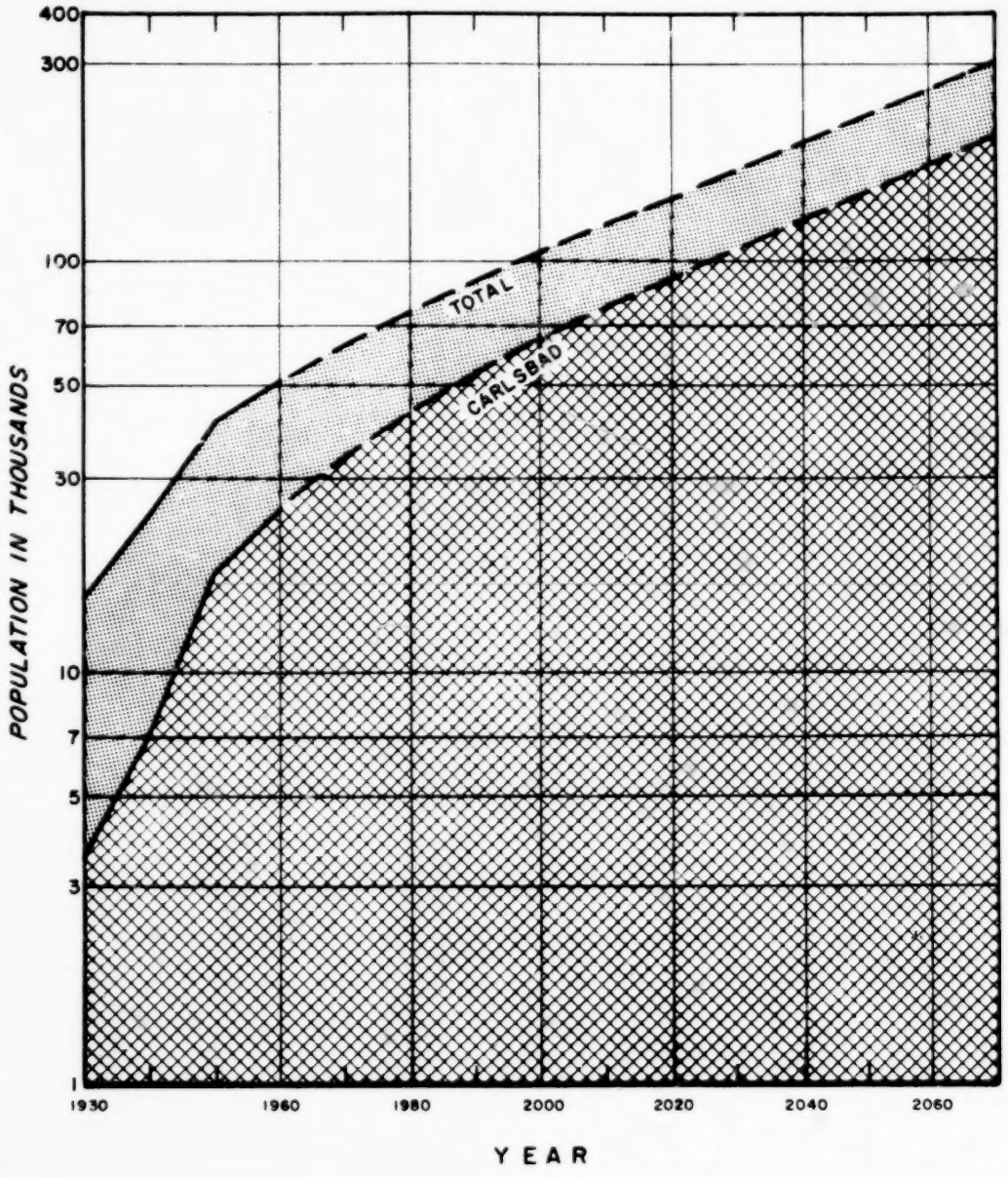
Historic and projected populations for the study area and the city of Carlsbad are given in table VI-6, and illustrated in figure VI-1.

Table VI-6

Historic and Projected Populations
for the Study Area and Carlsbad, 1930-2070

Historic*			Projected		
Year	Study Area	Carlsbad	Year	Study Area	Carlsbad
1930	15,842	3,708	1980	75,000	43,000
1940	24,311	7,116	2000	105,000	65,000
1950	40,640	17,975	2020	143,000	90,000
1960	50,783	25,541	2070	301,000	200,000

*Source: Bureau of the Census 13/



WATER QUALITY CONTROL STUDY
BRANTLEY RES.–PECOS RIVER–NEW MEXICO

POPULATION TRENDS & PROJECTIONS

UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
SOUTH CENTRAL REGION JUL. 22, 1966 DALLAS, TEXAS

FIGURE VI–1

VII. WATER REQUIREMENTS

In this study, water requirement projections serve as a basis for estimating future waste flow and the effect of discharging this waste to a watercourse.

Past and Present Water Demand

Municipal and Industrial

Historic water demand data for Carlsbad are presented in table VII-1 for the years 1946 through 1962. Municipal water as defined here includes residential, commercial, public, those industrial uses that are supplied from municipal systems and include losses in distribution systems and treatment plant attenuation.

Table VII-1

Carlsbad Municipal Water Demand, 1946-1962

Year	Total Use (mgd)	Estimated Population Served (1,000's)	Average Demand (gpcd)	Average Base Use Dec, Jan, Feb (gpcd)
1946	2.6	13.6	191	112
1947	2.9	14.7	197	116
1948	3.0	15.8	190	103
1949	2.7	16.8	161	95
1950	3.0	18.8	160	108
1951	4.1	18.7	219	128
1952	4.7	19.4	242	135
1953	5.4	20.2	267	140
1954	5.4	21.0	257	119
1955	5.4	21.7	249	123
1956	6.2	22.5	276	132
1957	5.9	23.2	254	139
1958	5.2	24.0	217	100
1959	5.1	24.7	206	116
1960	5.9	25.5	231	116
1961	5.8	26.3	221	105
1962	5.9	27.0	219	122

Source: City of Carlsbad Water Department 4/

United States Potash Company has a water right to 4,639 acre-feet annually and 15 second-feet of continuous flow from the Pecos River. Five other firms engaged in potash production in Eddy County use ground water.

Future Water Requirements

Municipal and Industrial

Future municipal and industrial water requirements in the study area were based on analyses of unit water requirements coupled with economic and population projections, as presented in Chapter VI.

Water use by the city of Carlsbad is influenced by precipitation. The per capita use has varied from 276 gpcd in 1956 (drought year) to 160 gpcd in 1950 (high precipitation year). In 1962, an average precipitation year, the demand was 219 gpcd. A base flow, or the amount of water used by the community regardless of precipitation affected uses such as lawn irrigation, was determined for the winter months (December, January, and February). Based on the historical trend shown in table VII-1, the base flow was extrapolated to 2070. Water use influenced by precipitation was assumed to be for a year with rainfall having a recurrence interval of 50 years. Therefore, the total unit municipal water requirement for the study area was evaluated to be 290 gpcd in 2020 and 310 gpcd in 2070. It should be noted that these future per capita water uses are for periods of low precipitation and streamflow. The average per capita value, based on average precipitation conditions, would be about 250 gpcd in 2020.

The municipal water requirement of Carlsbad is expected to be 26 mgd in 2020 and 62 mgd in 2070.

The definition of industrial water use here refers to all water regardless of source used by the manufacturing industries (Standard Industrial Classification categories 13, 14, and 20 through 39). The total industrial requirements are determined by combining the projected number of employees with the expected unit employee water use for each of the several industrial categories, 14, 15/ as shown in table VII-2. Mining and manufacturing related to mining are projected as the major industrial water users in the future. Industrial water use for Carlsbad for the years 2020 and 2070 is estimated to be 14 mgd and 23 mgd, respectively. The base data was obtained from similar adjoining areas, and adjustments have been made for anticipated recirculation and reuse practices.

Therefore, the total municipal and industrial water requirement for Carlsbad is expected to be 40 mgd in 2020 and 85 mgd in 2070.

In New Mexico far more water is used for irrigation than for any other purpose. It is anticipated that water used for irrigation in the study area, which is primarily ground water, will continue at approximately the same level as that of recent years.

Table VII-2

Future Unit Industrial Water Use
(gal. per employee day)

Item	2020	2070
Mining (SIC 13, 14)	1,480	1,480
Manufacturing		
Furniture, Lumber & Wood (SIC 24, 25)	730	825
Primary Metals (SIC 33)	7,350	8,280
Food & Kindred (SIC 20)	1,860	2,100
Chemicals & Allied Products (SIC 28)	1,875	2,018
Stone, Clay, and Glass Products (SIC 32)	2,030	2,290
Petroleum (SIC 29)	7,750	8,750
Other Nondurables (SIC 30, 31)	686	770
Fabricated Metals (SIC 34, 35, 36, 37, 38)	155	175
Textile & Apparel (SIC 22, 23)	280	316
Printing & Publishing and Not Elsewhere Classified (SIC 27, 39)	80	100

VIII. WATER QUALITY CONTROL

General

Water quality control is defined as any measure employed to enhance the utility, value, and attractiveness of waters used for purposes which are affected by changes in water quality. The use of water by man in his many activities and the subsequent return of waste effluent even after secondary treatment, causes some degradation of water quality. As population and the associated water demand increases, the problem caused by waste water becomes more significant. If the quality of the stream receiving this treated waste is reduced below acceptable limits, additional water is necessary to maintain acceptable conditions. This report is concerned with the possible use of releases from Brantley Reservoir for maintaining acceptable conditions in the Pecos River.

Water Quality Objectives

Evaluation of future stream conditions and the subsequent need for water quality control in the study area is based on parameters of water quality which are currently available for use. Dissolved oxygen content and dissolved solids were selected as the water quality objectives of this study. Dissolved oxygen is used to measure the effect of organic waste load upon the stream. It is one of the most meaningful measures of water quality for which predictive techniques can be applied. Dissolved oxygen is a significant factor in maintaining an environment for propagation of fish and other aquatic life. The amount of dilution flow required to maintain 4 mg/l or better of dissolved oxygen throughout the influenced stream was used since (1) it provides an acceptable environment for most aquatic life native to this area; and (2) it provides a buffer zone in the event unforeseen spills of waste occur. Dissolved solids are employed to characterize the effects of stable pollutants (those constituents which are not utilized or reduced by the stream environment) such as chloride and sulfate salts.

Presently, use of water from the Pecos River in the affected reach of the stream is for irrigation and one industry; there are no anticipated municipal and/or additional industrial water users. Because of this, total dissolved solids (TDS) are not considered a problem at the concentrations found in this area. Therefore, consideration of storage for water quality control is for fish and wildlife, recreation, and aesthetic purposes.

Municipal and Industrial Pollution

Stream Loading

Treated effluent from the Artesia sewage plant is presently used for irrigation and/or discharged to the Pecos River above the proposed Brantley Damsite. The location of the discharge point precludes the use of releases from Brantley to dilute possible unacceptable quality conditions in the Pecos River resulting from Artesia's waste flow.

Return flow from the city of Carlsbad is discharged to the Pecos River at mile 460. The average discharge from 1960 through 1962 was 2.5 mgd 4/ with a population equivalent (P.E.) of approximately 2,000. 16/ Waste disposal facilities providing secondary treatment are satisfactory under present conditions.

The projected municipal and industrial return flow of Carlsbad was estimated to be 36 percent of the water use and have an untreated ultimate BOD of 290 mg/1. Future water quality control requirements are based on the provision of sufficient treatment of the waste flow to remove 90 percent of the first stage BOD. This is considered technically feasible and economically reasonable at this time. Since water in this area of the country is scarce, it is reasonable to expect at least this degree of treatment to obtain maximum use from the resources available. Thus, the return flow is expected to increase to about 13 mgd in 2020 (P.E. of 13,000), and 30 mgd in 2070 (P.E. of 30,000).

The mineral quality of surface water in the affected reach of the Pecos River is high with an average of about 3,000 mg/1, as described in detail in Chapter V. Dilution releases from Brantley for this purpose would not significantly alter the quality of the Pecos River since the water stored in the proposed reservoir would not be of significantly better quality.

Flow Regulation

In investigating the organic pollution of the affected reach of the Pecos River, the oxygen-sag equation was used to calculate the concentration of dissolved oxygen (DO) in the river. The amount of dilution flow required to maintain 4 mg/1 of DO at the critical point in the river was determined for each month for present and future conditions. From these studies, municipal and industrial treated waste flow from Carlsbad that is discharged to the Pecos River is expected to degrade the organic condition of the river to undesirable levels by the year 1990.

Table VIII-1 shows monthly tabulations of dilution flow requirements (total need) for 1960, 2020, and 2070. In addition, the draft-on-storage* (total need less streamflow) by months at various probability levels for the years 2020 and 2070 are given in table VIII-1. Using an exceedence frequency of 95 percent, the draft-on-storage requirement is 4,600 acre-feet per year by 2020 and about 21,000 acre-feet per year in 2070. These releases would provide acceptable dissolved oxygen conditions in the reach of the Pecos River from Brantley to Red Bluff Reservoir, a distance of about 137 miles.

The additional yield of Brantley Reservoir for water quality control, which does not include that consiged to McMillan Reservoir (partially inundated by Brantley), would be an amount based on the water rights of the land that is inundated below McMillan Reservoir. For preliminary planning purposes, the Bureau of Reclamation has estimated this yield to be 7,000 acre-feet per year, which could be used for water quality control purposes and would be sufficient to meet this requirement until about 2032. A final dependable yield would depend on the actual water rights granted by the State Engineer in the transfer of water rights, the operation of the reservoir for optimized multipurpose use, and other legal and technical considerations.

* Annual draft-on-storage is the sum of the incremental excesses of needed releases over inflows during a climatic year.

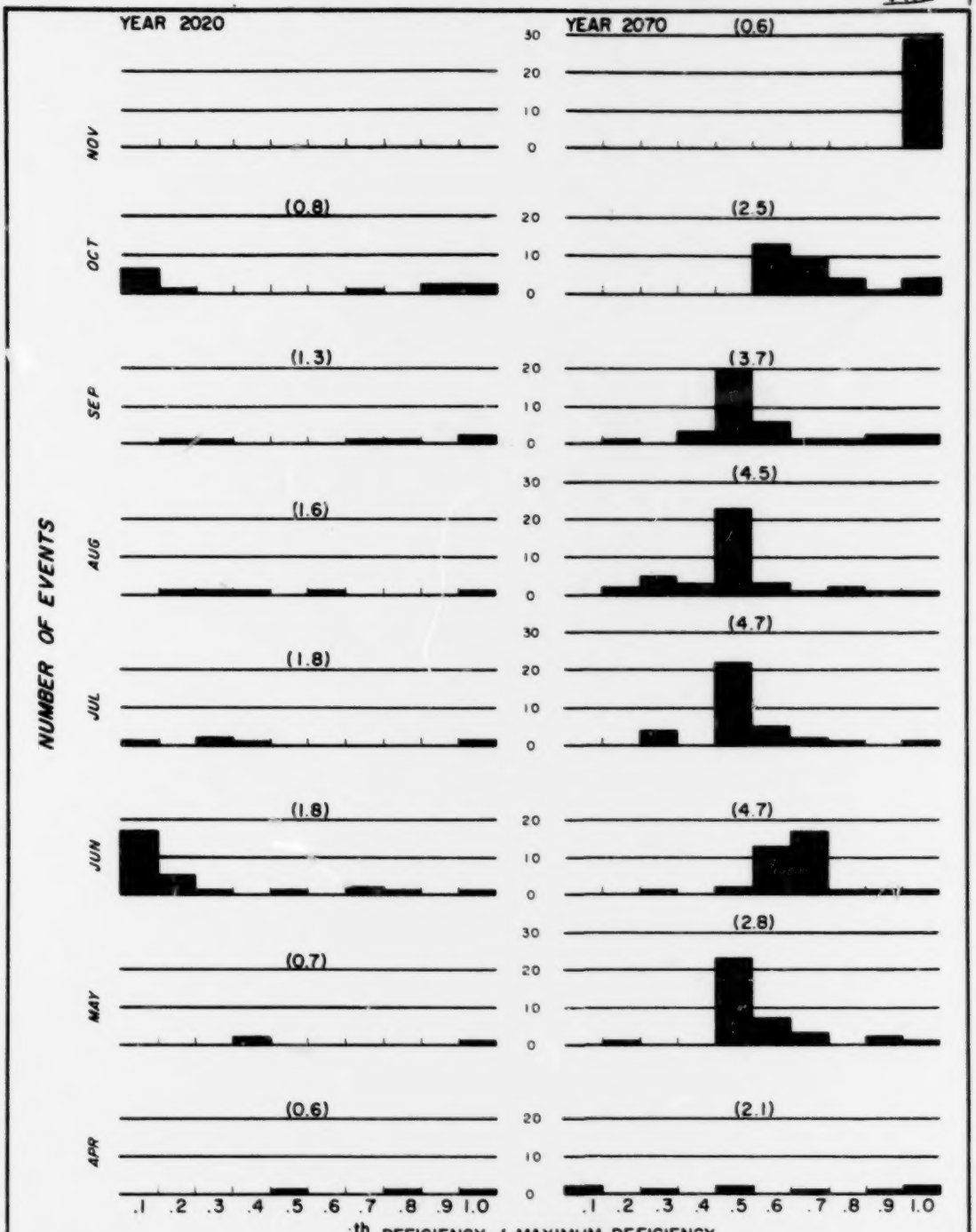
Table VIII-1

Water Quality Control Requirements

Month	1960 Dilution Flow Requirement ($AFx\ 10^3$)	2020 Dilution Flow Requirement ($AFx\ 10^3$)	2020 Draft-on-Storage at Various Exceedence Frequencies ($AFx\ 10^3$) 80%	90%	95%	2070 Dilution Flow Requirement ($AFx\ 10^3$)	2070 Draft-on-Storage at Various Exceedence Frequencies ($AFx\ 10^3$) 80%	90%	95%
Jan.	0	0.5	0	0	0	0.9	0	0	0
Feb.	0.1	0.8	0	0	0	1.5	0	0	0
Mar.	0.1	1.1	0	0	0	2.2	0	0	0
Apr.	0.2	1.4	0	0	0.3	2.9	0	1.1	1.8
May	0.3	1.8	0	0	0.3	3.9	1.6	1.9	2.4
Jun.	0.4	2.6	0.3	0.9	1.2	5.5	3.2	3.8	4.1
Jul.	0.4	2.6	0	0.1	0.5	5.5	2.5	3.0	3.4
Aug.	0.4	2.6	0	0.4	0.6	5.5	2.3	3.3	3.5
Sep.	0.4	2.1	0	0.4	1.0	4.5	2.1	2.8	3.4
Oct.	0.2	1.5	0.1	0.6	0.7	3.2	1.8	2.3	2.4
Nov.	0.1	0.9	0	0	0	1.7	0.6	0.6	0.6
Dec.	0.1	0.7	0	0	0	1.3	0	0	0
Total	2.7	18.6	0.4	2.4	4.6	38.6	14.1	18.8	21.6

These values should not be taken as an operating plan but as a reasonable basis for design of storage facilities. Actual loads will, in all probability, vary from projected values. Also, quantity and quality of runoff, temperature, quality of impounded water etc., will differ in field operations from the theoretical assumptions used in the calculations. Therefore, operation of the reservoirs for water quality control must rely on a monitoring system on the subject stream which will reflect actual conditions and use of the U.S. Weather Bureau's stream forecasting service. It should be noted that continuous flow in the river should be maintained for fish and wildlife. If all water is diverted for irrigation at any given time, a damage would result.

Histograms of dilution flow deficiencies for 43 years of record (total requirement less flow in the Pecos River at Carlsbad) are shown in figure VIII-1 for the years 2020 and 2070 with Brantley Reservoir in place. These graphs illustrate the severity



NOTE:

Conditions for Pecos River at Carlsbad with Brantley Reservoir in.

Maximum deficiencies for each month are shown in parenthesis at the top of each plot and are in 1000 acre-feet.

WATER QUALITY CONTROL STUDY
BRANTLEY RES.-PECOS RIVER-NEW MEXICO

HISTOGRAMS OF DILUTION FLOW DEFICIENCIES

UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
SOUTH CENTRAL REGION May 10, 1966 DALLAS, TEXAS
Rev Jul 6, 1966

FIGURE VIII-1

frequency of these flows for the months of need. Maximum deficiency values are given in parenthesis for each month at the top of the individual plots and must be considered in conjunction with the graphs in appraisal of the total condition. Thus, these histograms show the frequency and severity pattern of failure if releases from Brantley for water quality control purposes are not made.

Table VIII-2 shows the flow required (in addition to streamflow) at various probability levels to maintain 4 mg/l of DO in the reach of the Pecos River studied, without Brantley Reservoir.

Table VIII-2

Dilution Requirements Without Brantley

Probability Level (%)	1000 Acre-Feet Per Year		
	1960	2020	2070
80	0	1.9	17.6
90	0	6.1	22.9
95	0	7.9	25.1

It should be noted that return flow, especially during low flow conditions could be used for irrigation in the future. Normally, irrigation is practiced about eleven months of the year, the average frost-free period for this area being from April 7 to November 5. This period corresponds to that when additional flows are required to dilute the undesirable conditions resulting from waste discharged to the river as shown in tables VIII-1 and VIII-2. Therefore, if future return flow is used for irrigation, storage in Brantley for water quality control purposes would not be required. Further discussion of this alternative is presented in Chapter IX of this report.

IX. BENEFITS

Water Quality Control Storage Benefits

The benefits attributable to storage in Federal reservoirs for water quality control are defined as the net contribution to public health, safety, economy, and effectiveness in use and enjoyment of water for all purposes which are subject to detriment or betterment by virtue of change in water quality. Senate Document No. 97 states:

> "The net contribution may be evaluated in terms of avoidance of adverse effects which would accrue in the absence of water quality control, including such damages and restrictions as preclusion of economic activities, corrosion of fixed and floating plant, loss or downgrading of recreational opportunities, increased municipal and industrial water treatment costs, loss of industrial and agricultural production, impairment of health and welfare, damage to fish and wildlife, siltation, salinity intrusion, and degradation of the esthetics of enjoyment of unpolluted surface waters, or, conversely, in terms of the advantageous effects of water quality control with respect to such items. Effects such as these may be composited roughly into tangible and intangible categories, and used to evaluate water quality control activities. In situations where no adequate means can be devised to evaluate directly the economic effects of water quality improvement, the cost of achieving the same results by the most likely alternative may be used as an approximation of value."

Maintenance of good water quality in the Pecos River will make available water oriented recreation, such as, boating and fishing for area residents. In addition, riparian property owners will enjoy the aesthetic enjoyment of the stream stemming from the assurance of clean surface waters and a satisfactory public health environment at all times. Without flow regulation, the projected waste loads, even with adequate treatment, will result in increasingly frequent low dissolved oxygen conditions in the stream. This will result in loss of present and/or potential fish populations, loss of recreational values, and, in many cases, decline of property values in areas contiguous to the stream.

Since water quality control management by releases from Brantley Reservoir would contribute to the maintenance of acceptable dissolved oxygen concentrations in the Pecos River for a distance of approximately 140 river miles, providing the benefits described above, benefits from this storage in the project are considered widespread in scope.

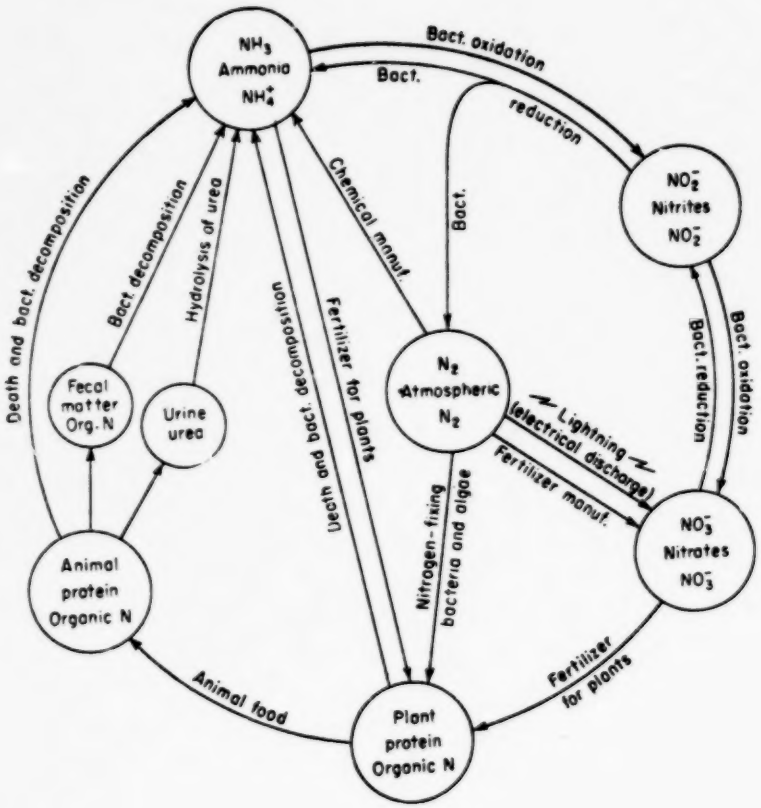
Several alternative methods to provide acceptable dissolved oxygen concentrations in the reach of the river studied were considered and are explained below. A cost analysis for each of the alternatives is presented in the Appendix to this report. In evaluating the benefits, the period of study was to the year 2070 (100-years) and a 3 1/8 percent interest rate was used. Construction facilities in all plans were considered to be structurally capable of a 100-year life, with periodic minor repair as needed (included in the annual operation and maintenance cost). The cost of replacing mechanically operated equipment, such as pumps, motors, and chemical-feed devices, is likewise included in the annual operation and maintenance cost. These analyses do not consider replacement of facilities due to obsolescence as it is felt this variable is beyond the scope of this report.

The application of advanced waste treatment methods to Carlsbad's sewage for a higher degree of first-stage BOD removal was investigated. To maintain a minimum dissolved oxygen concentration of 4 mg/l, sufficient waste treatment must be provided to remove 93 percent of the BOD in 2020, and 96 percent in 2070. A foam separation plant would remove 93 percent of the first-stage BOD while a lime-alum coagulation and sedimentation plus adsorption plant would remove 96 percent of the BOD. 17/ The average annual cost of this plan is $98,000.

This method does not appear to be a true alternative to storage for dilution flow, however, since it may not achieve the same results. Although the first-stage BOD of a sewage can be reduced to maintain acceptable dissolved oxygen levels in the stream, an additional oxygen demand is exerted as a result of (a) second-stage BOD in the waste discharge, and (b) the decay of algae that utilize nutrients in the waste discharge and natural flow for food.

To explain further, the oxygen demand on a stream is exerted by two classes of materials: carbonaceous organic material (first-stage BOD), and oxidizable nitrogen (second-stage BOD), which occurs primarily as free ammonia nitrogen and organic nitrogen. The second-stage BOD is exerted when oxidizable nitrogen is oxidized to nitrites and then nitrates by bacterial decomposition of organic matter. They are then used as food for algae for further growth. An additional secondary BOD results from the death and decomposition of these algae. As a result, nitrogen and phosphorus again become available for plant food. This cyclical effect, as shown in figure IX-1, can occur several times in a reach of a stream.

As the first-stage BOD is reduced by treatment, dilution water needs are no longer determined by disposal of BOD but, rather, for disposing of nitrogen and phosphorus. Conventional advanced waste treatment methods currently available for planning purposes will remove as high as 97 percent of the phosphate and 75 percent of the nitrogen. Streams receiving highly treated effluent tend to develop



WATER QUALITY CONTROL STUDY
BRANTLEY RES.-PECOS RIVER - NEW MEXICO

NITROGEN CYCLE

UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
SOUTH CENTRAL REGION AUG. 2, 1966 DALLAS, TEXAS

FIGURE IX-1

algal pollution immediately below the point of discharge while those receiving poorly treated wastes will generally develop algal growth further downstream. 17 18/

The upper level of permissible concentration of available nitrogen, if algal trouble is to be prevented, appears to be about 1.0 mg/l. 18/ In the Pecos River at Carlsbad, the weighted average of nitrates alone, exclusive of organic nitrogen, ammonia nitrogen, and nitrites, is about 5 mg/l. Even if it were possible to remove all of the nitrogen and phosphorus in the sewage waste, natural streamflow would contain sufficient nutrient concentrations to cause algae growth, which in time decay and exert a demand on the dissolved oxygen of the stream.

In a range somewhere near the 90 percent first-stage BOD removal lies a particular degree of treatment beyond which it is not practical to treat for organic conditions in the stream. This value is highly variable, depending on stream characteristics and environment, the unpredictable nitrogen cycle, and the nutrient loads. Information to develop the optimum treatment of waste flow for BOD removal is limited. It is questionable that the assimilative capacity of the stream, as effected by the nutrients, would be sufficient to maintain dissolved oxygen concentrations above acceptable limits even with advanced waste treatment.

A second alternative investigated was the use of the adequately treated sewage effluent from Carlsbad for irrigation. Since the quality of this effluent is better than the flow in the Pecos River into which it is presently being discharged, it seems logical that the effluent would be used for irrigation. A stage-construction pipeline system some 3 miles in length pumping against a 70-foot head was designed to transport the effluent to the existing Southern Canal which supplies water to the Carlsbad Irrigation District. Because of the nature of New Mexico water laws, the water rights to this effluent water would have to be purchased. However, the effluent could be sold to irrigators as an annual revenue of this system. This plan would have an average annual cost of $33,000.

Finally, a single-purpose reservoir at the proposed project site, since alternative sites nearby are not available, was examined. First the capital cost was converted to an equivalent annual cost (100 years @ 3 1/8 percent) and added to the annual operation and maintenance cost. Since storage in Brantley Reservoir for water quality control purposes is not needed until the year 1990, the 100-year reservoir life would extend the economic evaluation beyond the time limits of this study and the Bureau of Reclamation's study, which is to the year 2070. To be consistent with the time period used for calculating benefits for other uses in this multi-purpose

reservoir, the capital cost for the 80-year period from 1990 to 2070 was determined. The capitalized cost was then discounted to "present" 1970 values and amortized for 100 years to give an average annual cost of $579,000.

Since the only available storage in Brantley Reservoir for water quality control purposes (7,000 acre-feet per year) would not provide acceptable dissolved oxygen concentrations beyond about 2032, the benefits were reduced to reflect this condition. Using the most likely alternative of irrigating with the sewage effluent from Carlsbad, the cost of a comparable system was calculated. This plan would irrigate with the effluent in excess of the 1990 quantity until it reached 15 cfs in 2032; this quantity of effluent would remain the same to the year 2070. On this basis storage in Brantley Reservoir for water quality control purposes will have an annual value of $22,000. A summary of the cost computations used in this evaluation is presented in the Appendix on page 6.

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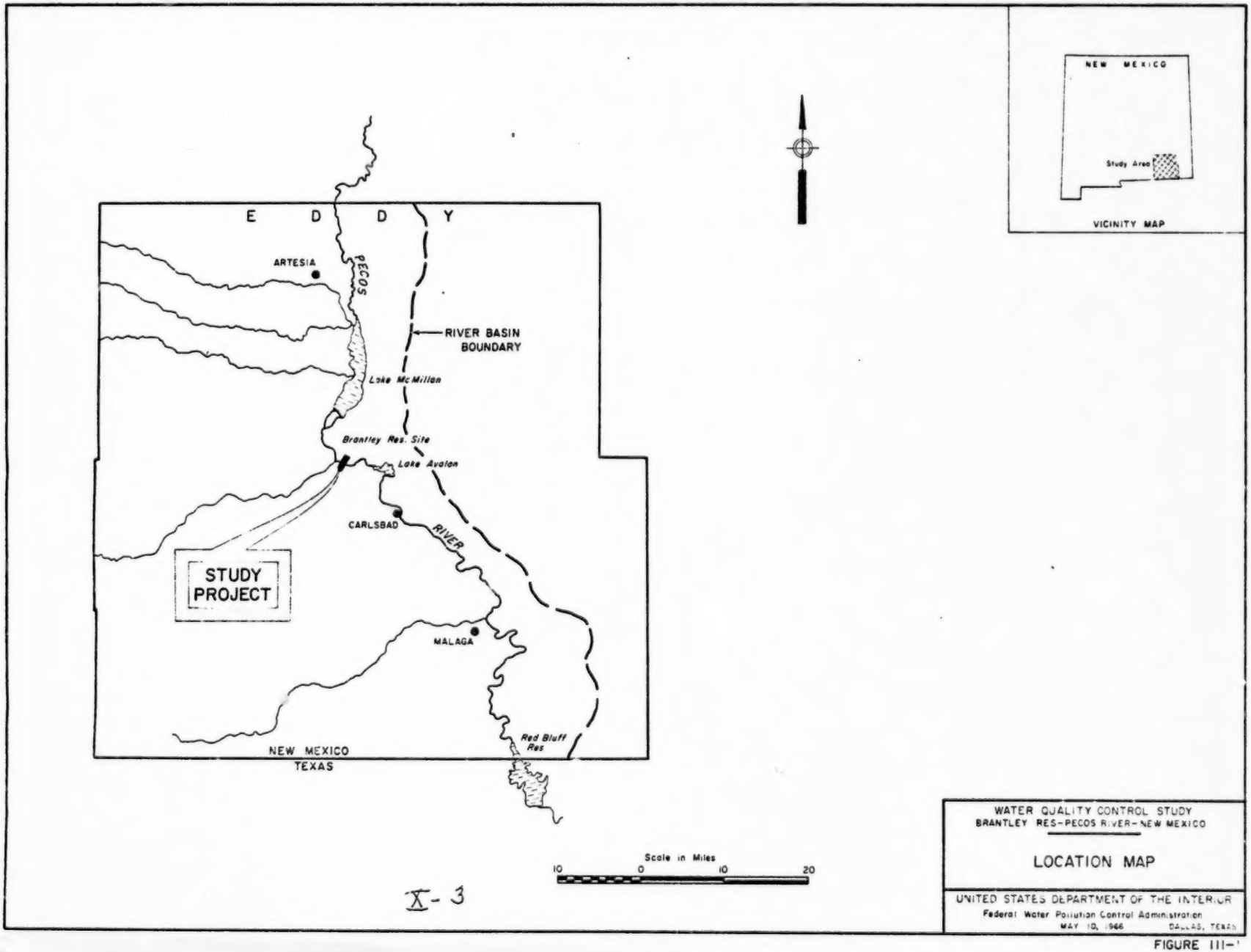

X-3

FIGURE III-1

APPENDIX

Summary of Alternative Cost Computations for Water Quality Control Benefits

Plan 1 - Advanced Waste Treatment Methods

Treatment to remove more than 90 percent of the first-stage BOD is needed by the year 1990. By 2020, 93 percent BOD removal is required and by 2070 about 96 percent BOD removal is necessary.

1990 System: 13 mgd Foam Separation Plant

First Cost:	$390,000
Annual Cost:	
Amortize First Cost for 100 years @ 3 1/8%	$ 12,800
Average Operating & Maintenance Cost	32,900
	$ 45,700
Capitalized Cost for 80 years	$1,337,700
Discount 20 years to 1970	$722,400
Amortize 100 years @ 3 1/8%	$ 23,700

2020 System: additional 6 mgd Coagulation-Sedimentation and Adsorption Plant

First Cost:	$1,750,000
Annual Cost:	
Amortize First Cost for 100 years @ 3 1/8%	$ 57,300
Average Operating & Maintenance Cost	119,300
	$176,600
Capitalized Cost for 50 years	$4,438,000
Discount 50 years to 1970	$954,200
Amortize 100 years @ 3 1/8%	$ 28,000

2045 System: additional 9 mgd Coagulation-Sedimentation and Adsorption Plant

First Cost:	$2,250,000
Annaul Cost:	
Amortize First Cost for 100 years @ 3 1/8%	$ 73,700
Average Operating & Maintenance Cost	117,000
	$190,700
Capitalized Cost for 25 years	$3,274,300
Discount 75 years to 1970	$324,300
Amortize 100 years @ 3 1/8%	$ 10,600
Total Annual Cost of Plan 1	$ 62,300

Plan 2 - Use of Adequately Treated Sewage Effluent from Carlsbad for Irrigation

Design Data for Transmission Line:
Discharge (cfs):
1990 - Year of first need
2020 - 10
2050 - 25
2070 - 37
Static Head - 70 feet
Distance - 2.9 miles

1990 System: 10 cfs

First Cost:	
24" R.C.P.	$196,000
Pumping Plant	130,000
	$326,000
Annual Cost:	
Amortize First Cost for 100 years @ 3 1/8%	$ 10,700
Average Power Cost + Operation and Maintenance	10,500
	$ 21,200
Capitalized Cost for 80 years	$620,500
Discount 20 years to the Present (1970)	$335,100
Amortize over 100 years @ 3 1/8%	$ 11,000

2020 System: 15 cfs additional

First Cost:	
30" R.C.P.	$254,000
Pumping Plant	162,000
	$416,000
Annual Cost:	
Amortize First Cost for 100 years @ 3 1/8%	$ 13,600
Average Power Cost + Operation and Maintenance	13,100
	$ 26,700
Capitalized Cost for 50 years	$671,000
Discount 50 years to the Present (1970)	$144,300
Amortize over 100 years @ 3 1/8%	$ 4,700

2050 System: 12 cfs additional

First Cost:	
24" R.C.P.	$196,000
Pumping Plant	150,000
	$346,000
Annual Cost:	
Amortize First Cost for 100 years @ 3 1/8%	$ 11,300
Average Power Cost + Operation and Maintenance	7,500
	$ 18,800
Capitalized Cost for 20 years	$276,500
Discount 80 years to the Present	$ 23,500
Amortize over 100 years @ 3 1/8%	$ 800
Total Annual Cost of Transmission Line	$ 16,500
Water Rights Purchase (5,480 acres of irrigation land with a maximum water duty of 5 ac-ft/ac at a cost of $850 per acre)	$4,658,000
Amortize over 100 years @ 3 1/8%	$153,600
Annual Revenue from Selling the Sewage Effluent for Irrigation Use (5/ac-ft)	$137,000
Total Annual Cost of Plan 2	$ 33,100

Plan 3 - Single-Purpose Reservoir at the Proposed Project Site
(20.5 mgd yield)

First Cost: 1/	$28,437,000
Construction Cost: 2/	$ 1,333,000
Total Initial Investment	$29,770,000
Annual Costs:	
Amortize First Cost for 100 years @ 3 1/8%	$975,300
Operation, Maintenance and Major Replacement 2/	142,200
Total	$1,117,500
Capitalized Cost for 80 years	$32,710,000
Discount 20 years to the present (1970)	$17,663,000
Amortize for 100 years @ 3 1/8%	$578,600
Say	$579,000
Cost per 1,000 gallons at full utilization	7.7¢

1/ Cost from Bureau of Reclamation, Albuquerque Development Office

2/ Determined by Federal Water Pollution Control Administration

Value of Storage in Brantley Reservoir for Water Quality Control (7,000 acre-feet per year)

Transmission Line:

Discharge (cfs):
- 1990 - Year of First Need
- 2032 - 15
- 2032 to 2070 - 15
- Static Head - 70 feet
- Distance - 2.9 miles

First Cost:	
30" R.C.P.	$254,000
Pumping Plant	162,000
	$416,000
Annual Cost:	
Amoritze First Cost (100 years @ 3 1/8%	$ 13,600
Average Power Cost + Operation and Maintenance	16,000
	$ 29,600
Capitalized Cost for 80 years	$866,400
Discount 20 years to 1970	$467,900
Amortize (100 years @ 3 1/8%)	$ 15,300
Water Rights Purchase (2,180 acres of irrigation land with a maximum water duty of 5 acre-feet/ac at a cost of $850 per acre)	$1,853,000
Amortize (100 years @ 3 1/8%)	$ 60,700
Annual Revenue from Selling the Sewage Effluent for Irrigation Use ($5/ac.-ft.)	$ 54,500
Total Cost	$ 21,500
Say	$ 22,000